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Copyright. Authors of papers and articles are requested to transfer their copyright to the Institution for a period of six months from the date of receipt of the paper. Such transfer should be made in writing when the manuscript is forwarded to the Editor.

Editors are permitted to publish abstracts, providing that acknowledgment is made to The Institution of Petroleum Technologists.

Issue of Journal. The Journal is issued in nine parts per volume, commencing in January of each year, with occasional extra numbers when necessary. The Title Page, Table of Contents and Index to each volume are published in the second issue of the succeeding volume.

Members whose subscription is not in arrear receive the Journal free of cost, and additional copies are charged at the rate of 7s. 6d. per part, unless otherwise stated. A member whose subscription is not paid by March 31st of the year for which it is due is considered to be in arrear.

Changes of Address. Members are requested to notify any change of address to the Secretary.

Papers and Articles. Members are invited to submit papers to be read at the General Meetings of the Institution, and are specially asked to forward articles for consideration for publication in the Journal. Diagrams, illustrations, etc., should be suitable for direct photographic reproduction.

Authors of papers published in the Journal are entitled to receive 25 free reprints of their contribution. Further copies may be obtained on payment, and orders for these should be sent to the Secretary when the manuscript is forwarded to the Editor. The free reprints do not include any discussion which may be published with the paper, but authors may have such discussion included in their reprints on payment of the additional cost.

Galley proofs of the paper to be read at a General Meeting are available at the time of the meeting, but members desirous of receiving such galley proofs in advance should apply to the Secretary.

Binding of Journals. Members desiring to have their Journals bound in cases should send them, together with a remittance of 5s. 6d. per volume, to Messrs. Speaight & Sons, Ltd., 98, Fetter Lane, London, E.C. 4. A charge of 7s. 6d. will be made for binding Vol. 10, 1924. Remittance in all cases must accompany the order.

Abstracts. Abstracts of the more important articles and patent specifications are published with each issue of the Journal, this supplement being paged independently of the transactions. Members desiring to have the Abstracts printed on one side of the paper only can be supplied with uncorrected galley proofs at a charge of 10s. per annum per copy, payable in advance.

Medals. The Redwood Medal is awarded, at the discretion of the Council, to the person who shall have made the most meritorious contribution to petroleum technology, in the form of a paper or papers published in the Journal of the Institution, during two successive sessions, preference being given to original work and to papers which have been read before the Institution and discussed. The award is not confined to members of the Institution and may be withheld if no contribution is considered to be of sufficient merit.

A medal and a prize of five guineas is awarded annually by the Council to that Student Member of the Institution who shall, in their opinion, have presented the best paper during the session.

Research Fellowship. The sum of £300 is allocated in each calendar year to a Fellowship for Research in technical and scientific problems which have a direct bearing on the Petroleum Industry. Additional grants, to a limit of £50 per annum, may also be made towards expenses.

The Fellowship is tenable for one year at an institution or in works approved by the Council, and may be renewed for a second year at the discretion of the Council.

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Applicants for the Fellowship must be in the hands of the Secretary of the Institution not later than June 1st of each year, and the necessary form, together with full particulars, can be obtained from him at Aldine House, Bedford Street, London, W.C. 2.

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Appointments Register. A register of members requiring appointments is kept at the office of the Institution for the convenience of firms requiring the services of petroleum technologists, etc., it being understood that the Institution accepts no responsibility and gives no guarantee.

Library. The Institution's Library may be consulted between the hours of 11 a.m. and 4 p.m. daily. (Saturdays, 11 a.m. to 1 p.m.)

PERSONAL NOTES OF MEMBERS AND SPECIAL NOTICES.

It is suggested that members send information regarding their movements to the Secretary, for insertion under this heading.

We offer our hearty congratulations to Professor J. S. S. BRAME on his being awarded the Order of C.B.E. in the New Year Honours List.

To Sir JOHN T. CARGILL we tender our deepest sympathy in the irreparable loss he has sustained on the death of Lady Cargill.

Mr. L. W. BERRY has left Peru and is in Ecuador.
Mr. W. E. D. COLE has left for Persia.
Mr. R. H. DEWALD is in Holland.
Mr. R. K. DICKIE has returned to Persia.
Mr. P. C. ERREY has left for Persia.
Mr. G. S. FFOULKES-JONES is in Venezuela.
Mr. R. M. FLETCHER has returned from Burma.
Mr. N. MATHESON has returned from Burma, via the U.S.A.
Ing. J. MENY has left Rumania and is in France.
Mr. H. F. MOON is home from Iraq.
Mr. P. J. RUSSELL has returned from Venezuela.
Dr. R. SCHIDER has left Sarawak and is in Switzerland.
Mr. D. SIMMONS has returned from Persia.
Mr. T. SPENCER, after a short stay in England, has returned to Rumania.
Mr. A. G. A. SUTTON has left for Burma.
Mr. L. N. WHITE has returned to Burma.

The Secretary will be glad to receive information as to the whereabouts of the following members :—C. A. BAUDUIN, J. C. FORTUNE, C. W. FULCHER, J. O. GUTHRIE, W. J. HARRIS, L. B. HOLLOWAY, W. JOHNSTON, A. F. C. PARKER, L. R. PHILLIPS, F. E. G. WATSON and L. K. WHITE.

The printers have inadvertently numbered the last issue of the JOURNAL (December, 1929) as No. 79 instead of No. 77. Those in receipt of this JOURNAL are requested to correct the number in order to avoid confusion.

OBITUARY.

FRANCIS RUSSELL.

MR. FRANCIS RUSSELL, who was born in Brisbane, Australia, was educated and completed his engineering apprenticeship in that country. He first visited Great Britain in connection with boring for coal in the neighbourhood of Dover, but his attention was drawn to the oil industry at an early date.

From 1899 to 1904 he acted as manager of a group of oil properties being developed in Russia by Mr. George Tweedy. He then went to Peru as General Manager of the Pacific Oil Company and undertook the pioneer operations of oil exploration in Peru. He first went to Rumania in 1908 and has been prominently associated with the petroleum industry in that country, where he was general manager to a group of companies which subsequently became part of the Phœnix Oil and Transport group.

During the war Mr. Russell took charge of munition factories at Burton-on-Trent and at Aintree, and was later appointed manager in Trinidad for the United British Oilfields of Trinidad. He subsequently returned to Rumania, and for several years past was manager of the National Supply Corporation's branch at Plœsti.

Mr. Russell has always taken a great interest in the affairs of the Rumanian Branch of the Institution, being a Member of the Committee. He was also interested in the International Club at Plœsti and the British Chamber of Commerce at Bucharest.

Mr. Russell had not been in good health for some time and a visit to London for medical advice showed an operation to be necessary. This operation was performed on November 25th, 1929, but unfortunately his malady was too far advanced for a successful result and he passed away on the same day without regaining consciousness. His death at the early age of 53 will be

deeply regretted by his many friends and by all who had the pleasure of knowing his charming personality. He is survived by his widow and a daughter and to them we tender our sincere condolence.

STANDARD METHODS OF TESTING PETROLEUM AND ITS PRODUCTS.

The second edition of the Institution's publication, "Standard Methods of Testing Petroleum and Its Products," has just been published. Since the publication of the first edition the Standardization Committee has been continuously at work, and as a result the tests have been revised where necessary and a number of new methods added. In addition, a section on the sampling of Petroleum Products has been included. The new book, which contains 137+xiv. pages and 30 illustrations, is interleaved with blank pages, and may be obtained from the offices of the Institution at 7s. 6d. net. Members of the Institution and *bona fide* students may obtain one copy for their personal use, marked "Member's Copy," at 5s. net.

JOURNAL OF THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

As an increasing demand has arisen for complete sets of the JOURNAL, arrangements have been made for the reprinting of numbers out of print, and the Institution is now in a position to supply complete volumes at a flat rate of 10s. 6d. per number if purchased direct from the Institution.

It has been suggested that the Transactions and the Abstracts should be bound separately in annual volumes. Any person wishing to take advantage of this proposal is requested to communicate with the Secretary.

Commencing this number the JOURNAL will be published in nine parts per volume, i.e., monthly from January to June and from October to December. The price of the JOURNAL will remain at 7s. 6d. per part, and the Annual Subscription will be £3 3s. In view of there being an unequal number of parts in each half year it will be impossible to accept half-year subscriptions at the yearly rate, and such subscriptions must be calculated at the published price of the number of individual parts required.

CONVERSAZIONE.

A Conversazione was held by the Institution of Petroleum Technologists at the House of the Royal Society of Arts, London, on December 19th, 1929, and was attended by about 130 members and their friends.

The members and their guests gathered in the Library, where refreshments were served and the following exhibits had been arranged :—

Anglo-American Oil Co.—Engine and testing set used for determining the anti-knock properties of motor fuels.

Asiatic Petroleum Co.—A series of native lamps, made from old milk tins, etc., as used by the natives of East Africa, Java and Malay, together with wicks made from the Gaboes reed. Also tokens used by the Company, owing to the shortage of coin during the war, as coinage in their own installation near Singapore, which soon became recognised as currency in the town.

W. Christie & Grey.—A laboratory size "Typhoon" patent agitator for obtaining intimate mixtures of oil and reagents.

Institution of Petroleum Technologists.—The original Redwood Viscometer.

International Telephone and Telegraph Laboratories.—Apparatus for the determination of the interfacial tension at an oil-acid surface during the examination and comparison of insulating oils.

University of Birmingham.—A number of samples of oil were on view, as follows : (1) Crude Oils from various parts of the world ; (2) Illustrating the Refining of Lubricating Oils by Liquid Sulphur Dioxide ; (3) Illustrating the Anti-knock Rating of Pure Hydrocarbons ; (4) Synthetic Oils from Coal ; (5) Synthetic Oils from Ethylene.

During the evening a very interesting film of the Petroleum Industry was shown by Mr. James Kewley. After Sir Frederick W. Black had made a brief speech to open the proceedings, Mr. Kewley explained that the film was an educational one prepared by the U.S. Bureau of Mines and the American Petroleum Institute to illustrate the various operations in the production of petroleum and its products, and he expressed his indebtedness to the U.S. Bureau of Mines for permission to use the film. He also showed two reels illustrating the laying of a 1400-mile pipe line from West Texas to Chicago City.

At the conclusion of the film, the President, Dr. A. E. Dunstan, proposed a vote of thanks to Mr. Kewley for his kindness and trouble in showing the film, and this was carried with acclamation.

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THE PETROLEUM INDUSTRY.

A brief survey of the Technology of Petroleum based upon a Course of Lectures given by Members of the Institution of Petroleum Technologists at the Petroleum Exhibition, Crystal Palace, 1920.

This work will be found of value to students and those desirous of obtaining an elementary knowledge of the Technology of Petroleum.

A few remaining copies for disposal at 2s. 6d.

REPORT OF THE EMPIRE MOTOR FUELS COMMITTEE.

The complete Report of the Empire Motor Fuels Committee, containing valuable data relating to Fuels for Internal Combustion Engines.

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THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

The One Hundred and Twenty-Third General Meeting of the Institution of Petroleum Technologists was held at the Royal Society of Arts, John Street, Adelphi, London, on Tuesday, December 10th, 1929, Dr. A. E. Dunstan (President) occupying the Chair.

ELECTIONS AND NOMINATIONS.

The Secretary announced the following had been elected :—

As Members.—Carl Franklin Braun, George Walter Furniss, Frank Goldstone, George Hunter, Maung Maung, Thomas Taylor McCreath, F. Georg Mueller, Ernest Arthur Satchell, Howard Theophilus Wright.

Transference to Member.—Frank Leslie Garton.

As Associate Members.—Samuel Charles Anderson, Emanuel Dawidson, Cornelius Antoninius Aloysius Travers Dorans, Arthur George Fenn, William Herbert Harris, Humphrey Harvey Martin, Ernest Patrick Pink, Alexander Reid, Charles Arthur Ross, Edward Kenneth Sargison, Philip Alfred Stiff, Leonard Arthur Toone, George Albert Edward Walling, Jack Watson, Lancelot James Wilson, Alfred Samuel Wolfner.

Transference to Associate Member.—Oswald Augustine Bell, Neville Aspinall Clegg, Richard James Hayman, Donald Albert Howes, Kenneth Chesterton Johnson, Walter Beveridge Rowntree, Herbert Muggleton Stanley, Ernest George Thorn, George Scott Urquhart, Christopher John Ward, Leslie Newton White, Edward Flasby Whittingdale, Richard Llewelyn Wilson.

As Student.—Wilfrid Herbert Parsons.

As Associates.—Boris Dvorkovitz, Stanley George Green, William Deacon Jarvis, Donal Wheeler O'Brien, Tressilian Walter Ranson, William McKechnie Robson.

Transference to Associate.—John William Weitz.

At the Council Meeting held on November 12th, 1929, the following were nominated :

As Members.—Thomas Michael Hartigan, Percy Norman Hulme, Hugh McCallum MacIntyre, Malcolm Smythe Mainland, Jules Rimbaut, Casimir Zuber, Stanislaw Zuber.

As Associate Members.—Christopher Wilfred Percy Edmund Green, Alexander Thomas Spence Simpson.

Transfer to Associate Member.—Horace Vivian Steadman.

As Students.—Michael Ross Burnett, Duncan Alexander Cox Dewdney, Reza Khan Fallah, Roy Bruce Finnis, Alan Lancelot Greig, Norman George Gullick, Edward James Stanley Hewitt, George Douglas Hobson, Robert Elliott James, Charles Stirling Lee, Abbas Parkhideh, Paul Pewsner, Abol Hassan Khan Radjy, Alfred Siff, Richard Colin Simmonds, Adrian Jasper Ernest Swann, Theodorus Willem Te Nuyl, Edward Ernest Thorneloe.

At the Council Meeting held on December 10th, 1929, the following were nominated :—

As Members.—Bert Charles Frichot, Philip Morley Griffiths, Walter James Perelis, Claude William Burt Shorto.

Transference to Member.—Gwyn Elias, Henry Stuart Tegner.

As Associate Members.—William Parkinson Hirst, Stanley Lashmore Roberts, George Vernon Tullett, John Campbell Wright Robb.

As Students.—Henry Cecil Hastings Darley, Michael Everitt Kelly, James Francis Alexander Stark, Thomas Charles Gordon Thorpe.

As Associate.—Reginald Frank Alfred Baldwin.

The President said it was a very great pleasure to him personally to welcome Mr. Gillespie, first because it had been an honour to him to know Mr. Gillespie for many years, secondly because he had occupied a very high and honourable position in the industry, and thirdly because he was sure the paper would stand out not only as a record of technical achievement but also as an eminent literary effort.

The following paper was then read :—

The Engineer in Relation to the Petroleum Industry.

By John Gillespie, M.I.Mech.E., M.I.E.S. (Member).

It is sometimes useful and convenient to append to such a paper as this a summary of its salient points, or a résumé of the conclusions arrived at. It has occurred to me that it may be convenient for you if I place a summary at the beginning rather than at the close, as such a course may assist those who honour me, by listening or by reading, to follow the sequence of thought which has, I would say, gradually evolved itself, rather than appeared

as a whole, during my ruminations over a subject which I could not fully see while inside its scope, but which has from the outside become more interesting and more important the longer it was so regarded.

After an introductory sentence or two I will endeavour to define the word "engineer," firstly in its broadest sense, and then more explicitly, with a view to the classification of the engineering services, differentiating between the designing side and the constructional or operative branches. I will try to state the limits of the engineer's relations to the Petroleum Industry, as regarded from two extreme points of view. I will then make a definite claim as to the importance of these relations, and will proceed to bring evidence to bear in support of my case for this claim. Thereafter I will point out certain disabilities under which the engineer lies, more especially on the technical or designing side. I will have a few words regarding the education of the young engineer relative to the Industry, and will close with a word of outlook for the future.

You will find the paper couched in ordinary every-day language, rather than in terms of the academic. It has been written to convey the thought of one who has laid aside his armour to those who are still bearing the burden, and are still in the forefront of the fight, for there lies my claim—that the engineer *is* in the forefront, and forms, and will always form, the spearpoint in this line of attack upon the wonderful and bountiful resources which Nature has hidden near the surface of Mother Earth.

My first word must be one of thanks to Dr. Dunstan for asking me to read this paper, and for suggesting a subject, while my second word must be thanks to our Secretary for proposing the title which stands above this paper.

In his Presidential Address delivered in March, 1924, Mr. Herbert Barringer dealt with the same subject and used the same title. In the interval there has been much development in oil matters, and a restatement of the relations which exist between the Petroleum Industry and the engineer may not be amiss.

As a Scot I know and appreciate the value of a text upon which to discourse. There lies a certain charm in holding another responsible for the matter to be treated, and still a greater charm when that matter is so clearly defined, as has been done for me, in limiting the discussion of the engineer to his relationship to the Petroleum Industry. The subject might have been given wider limits, and might have ranged from the ingenious youth of the wireless set to the men who pierced the Alps or harnessed Niagara to useful production of energy. For your sake as well as my own the limitation is judicious.

But when this is said I find myself on the verge of difficulty—where lie the limits of such a subject as the engineer's relation to the oil industry? And here I must ask your forbearance—to an old engineer the temptation is urgent to indulge in propaganda for the profession to which he is proud to belong; and if I fail to suppress completely that temptation, will you grant that my subject sins against me, rather than that I myself am sinner? All men are more or less engineers. I have seldom met a man who did not agree with and appreciate the words of Rupert Brooke, who placed honourably among the things he loved

"The keen,
Unpassioned beauty of a great machine."

The suggestion that all men are to some extent engineers leads to the question, "What is an engineer?" Reference to the Oxford Dictionary proves that two columns of that most interesting and useful work are devoted to an attempt to provide an answer. The definitions are given in five groups, but only one of these groups will I inflict upon you:—

> "One who controls, designs or invents; an author, designer, an inventor, a plotter, a layer of snares."

The temptation to expatiate on that last definition, "a layer of snares," in relation to oil is so deliciously enticing that it must be sternly avoided. A simpler and more embracing answer might be phrased thus: An engineer is a man who thinks, and through thinking solves some practical problem. Taking this basic definition, it might reasonably be said that the earliest of the developments of Petroleum Technology, carried out as they were by men without technical training—the various production and refining problems being almost inevitably solved in a crude and inefficient manner—were nevertheless carried out by engineers, inasmuch as the men on the job, from Colonel Drake downwards, had certain conditions to meet and produced apparatus or methods to meet those conditions.

And the mention of Colonel Drake's name reminds me that I should say at the outset that it will be impossible for me to deal to-night with the historical aspect of the association of oil and engineering. My friend Mr. Hugh Allan, of Rangoon, has suggested that a very interesting paper might be prepared, dealing with the historical-geographical side of the development of engineering in relation to petroleum. In such a paper there would be studied America, as the great and initial producer; Russia as the first to undertake bulk transport in pipe lines; Scotland as the seat of the shale-oil industry—the names of Dr. Young and Norman

Henderson are not forgotten; the Continent in its development of fractionation and heat conservation, and so on. I pass on the suggestion to Dr. Dunstan and our Secretary for another time and another author. To-night I can only deal with things as they are, If I stray too much into the past the present will suffer by exclusion.

A wide and very general definition of the name or word "Engineer" has been suggested; it is essential now to go a little further in the direction of classification. There is the skilled mechanic or operative engineer, there is the highly-trained technical engineer who designs and plans, and there are all grades intermediate. It is interesting to note that almost coincidently with the growth of the modern Petroleum Industry, the status of engineers has become more closely defined, so that now we have at opposite ends of the great fabric of engineering ability the practical man or mechanic and the highly-trained technical man. In no branch of technology is it more true than in the Oil Industry to say that the practical man has not been superseded by, but rather that he has been helped by, the technical man. Those crude efforts by which the pioneers of the modern Oil Industry overcame their comparatively simple problems were seldom wrong in principle; and one has only to turn to the up-to-date oilfields of California or elsewhere to find how many of the earliest and most primitive devices still persist in principle, in the form of the latest and most improved derricks, rigs, draw-works and other well appliances. The work of the technical engineer has lain largely, if not mainly, in his co-ordination and development of those time-honoured principles in such a manner as to permit of the progress from the old-time isolated well to the great modern oilfield. And for the good of all concerned in the Industry, either Fields, Refinery or elsewhere, it is essential that the best possible relations should exist between the practical and the technical side. I have been on both sides, I was trained among moulders and blacksmiths, girder makers and tank builders, and for over thirty years I was as much concerned with construction and erection as with design, and I have never found it other than agreeable and interesting to work on either side.

I suggest that the study of the importance of the engineer to the Petroleum Industry may well be approached by stating through actual verbal illustrations the extreme limits "for" and "against" that importance. And the "against" will come first.

It was my misfortune some years ago to be present at a somewhat heated discussion between two men not unknown in the oil world of that day. I was neither arbiter nor umpire, in fact they had quite evidently forgotten my presence. In an unwise moment one

of them quoted in support of his view the opinion of the engineering world in general ; my feelings were spared to some extent by these two words " in general." The reply came hot and sharp, " Do you ever trust an engineer ? Are you not yet aware that he is an evil in the industry—possibly necessary—but certainly an evil." That is one limit of view, and I think it must be the ultimate in the direction of depreciation.

The contrast is a brighter and a warmer picture. One of our members was discussing the relative importance of the engineer in the oil world, with a layman, and when I use the term layman to-night, I mean one of the uninitiated, a non-technical. This layman became so enthused by our champion's eloquence that, thinking he would please him by a large and generous admission, he remarked " I grant you that engineering covers 85 per cent. of the industry." Before this Institution I dare not quote verbatim my friend's reply, which mildly rendered, took the wording, " May I ask what is the other 15 per cent." While not here claiming 100 per cent. penetration of the Industry's functions, I must at once indicate that I cannot agree that we are an evil in the Industry, however graciously the word " necessary " is added.

I had thought to discuss with you an imaginary oil industry, from which the engineer was eliminated. I cannot do so, the oil industry cannot exist apart from the engineer, either as designer or as operative. He is indispensable, and he is the only member of the staff who is entirely indispensable throughout the whole series of the Industry's activities and functions.

The petroleum industry discussed broadly relies upon the services of the Financier, the Administrator, the Geologist, the Chemist and the Engineer. The financier includes the shareholder, and both may be grouped with the administrator in a class which is non-technical, and absolutely dependent upon the technical side. The existence of the industry, apart from the financier and administrator, is a bare possibility, higher than that I will not put it. It is also conceivable that in these days of nationalisation, a Government department may be found capable of exercising the functions of the group named.

I would at once say that the Industry without the Geologist would progress—if progress at all—with the stumbling and hesitating step of the blind. It would sadly miss the guiding hand so necessary to original discovery and to the economical development of proved areas. In similar manner the industry would move—if move at all—in a groping and uncertain fashion, in the absence of the chemist's skill and research. But it is conceivable, barely conceivable, that an oil industry could exist without either Geologist or Chemist, but oil cannot be found, produced, moved, refined,

sold, or used, without the direct and constant interposition of the Engineer.

And now to prove this. I fear that the method may appear clumsy, but I see nothing better than a detailed following of the Industry's processes and a tracing of the engineer's relationship thereto.

We must begin at the source, and it will be convenient to start the examination at the point of prospecting, rather than to discuss the conditions on a proved field, as the initial stages are of very considerable interest. The first work to be done in a new area is a general survey for the purpose of estimating the possibility of the prospective oil field becoming a paying proposition. The geologist, after careful examination and study of the evidence accessible, will give his forecast of the total volume of oil available. The engineer has then to estimate the cost of the facilities necessary for the development of the field, and for delivering the oil to an existing or potential market. If the area is a long distance from the seaboard, and the local market is negligible, the cost of a pipe line, which may run into colossal figures, must be estimated, as also the cost of roads and possibly railways, water supply—in desert areas an important and expensive item—and a host of other details which need not here be specifically mentioned. In addition, the features of the climate and their effect on the possible development must be studied. There are known oil-bearing areas which cannot be opened up, because the engineering difficulties and the climatic conditions are such that no profit can be foreseen.

If the result of this general survey and estimate is favourable, a more detailed survey must be made for the determination of the site of the test well, and for purposes of its cost estimation. Again the first steps are those of the geologist, who after careful study, makes a definite recommendation to the administrative side. Much of the detail work which follows and which lies in the hands of the surveying, constructional and mechanical engineers, has already received the anxious consideration of the geologist. He has studied the possibilities of the location in many directions, and has not overlooked certain essentials which have so serious an influence upon the ease and convenience, or difficulty and danger, of carrying through the drilling of a test well. The second estimate which follows upon the geologist's decision as to a site, must be made in much greater detail than the first general survey, and falls into the hands of the expert and trained engineer. The possibility that the area may not prove so productive as the geologist has indicated must be kept in mind, and for this and other reasons such facilities as water supply, roads, housing, lighting, transport and sanitation must be framed in the cheapest form that conditions will

allow. The estimate must include the cost of drilling and the cost of all the tools and equipment required, and even the cost of abandonment, and the possible value of such plant and material as may be worth salvage, and the cost of such salvage if the test is a failure.

If on the figures shown by this final report the administration decides to proceed, the services of the engineer are once more called upon. Many of the major details of such an undertaking as is now before us, are so inter-related that they must be considered as a group and not individually. I refer to such matters as water supply, roads, access, transport and methods of operation. The first practical move is made when the surveying engineer plots upon an available map the possible lines of approach from rail-head or water port. It may be necessary for him to consider several lines of access, or one existing road may provide all he requires: a very unusual and unlikely bit of luck. Bridge building, the formation of culverts and the grading and construction of the road, all fall into the engineer's hands. But before he has determined the formation and character of the road to be built, he must consult the transport engineer as to the type, weight and speed of the vehicles which will make use of that road. And before the transport engineer can answer the question many points of detail must be fixed. A decision must be reached as to the type of motive power to be adopted for the operation of the drilling plant: this decision depends largely upon the fuel available, or most economically available. Coal or wood may be unobtainable at reasonable cost, fuel oil may be the most convenient, or petrol to be used in a specially designed drilling-engine. It is conceivable that the installation of a small electrical power station at rail-head may prove the most satisfactory solution. Such a decision would, of course, involve the erection and maintenance of a transmission line from rail head to the well location. If coal or wood are to be used, at the well, supplies must be carried over the road, at fixed rates and periods during the whole continuance of the test, and transport vehicles must be provided accordingly. If fuel oil or petrol are used, road tank wagons may be required. If steam at the well is to be the power medium, then boilers of probably 12 tons unit weight must be carried over the road, and its construction and the rating of the bridges and culverts must be arranged accordingly.

When the road is in being, the moving in of water supply plant, and building material is begun, and houses, stores and garages are erected. This is all purely civil engineering work, but it has to be tackled as a rule by the versatile oil field engineer. In any case it is an engineer who does it.

For an important test, a workshop of more or less complete description must be provided. The shop itself is probably a steel framed building, covered with the unsightly but very useful galvanised corrugated sheeting. Inside that shop there may be a lathe, a drill, a pipe screwing machine, even a small planer or shaping machine—there must of necessity be some power driven machine tools. To provide the building framework, smiths and girder makers have been at work, and steel bar and sheet mill rollers were employed to produce the covering; for the machine tools, moulders, smiths, turners, screwers and other highly skilled men were engaged, and each and all of them were mechanical engineers.

Nay, I will go further; before the engineer could lay out the lines of his first shed or building, before the surveyor could align his road, steel tape and footrule, dumpy level and theodolite had to be used, and thus the productions of engineers highly skilled in the manufacture of instruments of precision entered the service of the oil industry. I do not wish to labour the matter, but no one of these details is trivial, and all of them point in the one direction—the support of the case I set out to prove.

Then follows the erection of the rig and derrick, designed for rotary or for cable tool operation, or for a combination of both these methods. Very probably the decision is for a complete rig and derrick of steel construction. Many members of this Institution will be familiar with the reluctance of fields staffs to employ such improvements as steel rigs and derricks. Apart from the conservatism innate in all humanity, that reluctance was doubtless well founded in the first instance, since the earliest efforts at such improved plant were developed without a due measure of thought, without, in fact, the full services of the technical engineer. To-day we find in regular service steel derricks designed for, and quite capable of, standing up to working loads of 100 tons, without departing from the time-honoured factor of safety of four. These structures are definitely safer and handier than the derricks of wood which they replace, and have, moreover, a much longer life, extending probably to about twenty years.

Meantime, the drilling plant—again an engineer's product—has been ordered to specifications which must include every possible requirement from crown block to casing shoe, from engine to drilling tools, from boilers to fire-fighting apparatus. The amount of work involved in all this preparation can only be appreciated by those who have successfully gone through it, covering, as it does, every daily need of a small community, and of an engineering undertaking which may cost a quarter of a million pounds or more before it is completed.

Before announcing the advent of that much discussed and most valuable man—the driller—may we regard for a little one or two of the problems involved in drilling as carried out to-day. We will look at them only as they affect the engineer who must design plant to meet them.

For wells of limited depth, steel casing of lap-welded manufacture and of thickness and material not much differing from those of good quality steam tube, was in general use. When wells were pushed deeper, this material collapsed under the extreme external pressures exerted, and the casing maker had to apply to another branch of the engineering profession for assistance. The metallurgist came to his aid with the high carbon steel tube which is not manufactured by welding a strip, but is produced as a billet, is pierced, and is drawn from the solid without a weld. Casing of this type is now used in wells over 8000 ft. deep.

When the increase in well depth became general, difficulty arose in finding rotary drill pipe of sufficient tenacity of material to stand up to the abnormal strains it had to undergo. If the bit were turning at the end of a short stocky bar there is nothing abnormal in the condition, but I ask if you have ever tried to envisage a drill pipe 8000 ft. long and not more than 4½ in. diameter at any point, standing vertically or as nearly vertically as its emaciated form will allow. If it were not for the wall of the hole or the casing it could not stand upright at all. It must lie from side to side of the hole, quite irregularly, and when in action it is probable that there are several complete circles of twist between top and bottom, that is, that the bit is lagging several revolutions behind the rotary table at the top. It almost seems as if we were asking too much from steel, and yet these deep holes are drilled.

If we turn from the rotary side to the cable tool system, we have in the steel rope which names that older method another example of the terrible punishment to which material is exposed in the drilling world. I have as an inspecting engineer experienced more difficulty in the search for the perfect wire rope than in regard to any other item in the whole range of oil or other industry. On the subject of the wire rope, as a casing line in rotary drilling, I would refer you to Mr. B. J. Ellis's paper contributed to the Second International Drilling Congress and recorded in the current number of the Journal, pages 588-590. He there points out certain features in practice which amount to the punishment of the material of which I have spoken, and indicates lines along which amelioration is being secured.

To return to our examination—with all preliminary preparations completed, the driller arrives and sets to work. Until a few years ago the driller was looked upon as in a class apart, a special being

who needed no engineering training, but merely his experience to enable him to do his work. Unlike the miner, who used only pick and shovel, he has always used mechanical appliances for his work, and these appliances have now been so highly developed by the engineer that the driller has perforce to learn more and more of engineering to use them. At the present time matters are in a transition stage, but before long the engineer driller will have replaced the man with no engineering knowledge. This has already happened in the controlling grades of the drilling staff, which are now recruited almost exclusively from among engineers who have specialised in this new branch of the great profession.

When the well is drilled and oil found, the production man comes on the scene to bring the oil to the surface. In some cases the oil brings itself to the surface, but all instances are not so fortunate. Here again this section of the work was until recently considered the special province of a man with no other training than years of experience gave him. It has long been realised that existing methods of production result at best in the winning of a deplorably small proportion of the total oil-content of any proved sand. Intensive study of the matter by geologists and engineers has led to general acceptance of the importance of conserving the gas-content of the oil in the sand, but has not so far produced any generally applicable means to that end; neither has the ideal treatment yet been devised for such fields as have been produced for many years by old methods, and have, as a consequence, been largely denuded of gas. Developments in this direction are daily the subject of experiment in many important oilfields; to date the conclusion seems to be that, as for all other evils, prevention—avoidance or strictest curtailment of production of gas with the oil—is not only better but probably much easier than cure by "repressuring" or other similar process.

The development of the area from a single well into an oilfield of a size adequate to warrant the cost of a pipeline is a big engineering undertaking. In the early days a field grew up in a more or less haphazard manner. Plant was put down to meet to-day's needs and the morrow was left to look after itself, with the obvious and inevitable result that there was much scrapping of plant which had become unsuitable before it had worn out, and expenses were high. To-day development problems are tackled by the engineer, directed as to certain lines by the geologist, and works are visualised in their final form to meet stated oil outputs, and development work proceeds along the orderly lines of addition instead of by chaotic and expensive substitution.

Ten years ago practically the only source of power used on the world's oilfields was steam, generated by consumption of an

appallingly large proportion of that very material it was the aim of the fields staffs to produce. It may safely be prophesied that within another ten years practically every established oilfield will be operated by more economical forms of power-generating plant. It may be interesting here to interject a comparison of the approximate fuel-costs of generating one horse-power-hour by various means :—

Internal combustion engines at full load—direct application	1·00
Electrical plant with internal combustion engines as prime movers ..	1·25
Internal combustion engines running normally below their rated load	1·50
Electrical plant with steam turbines as prime movers	2·00
Usual type of fields steam engines and boilers	7·00

In its application to the problem of reducing fuel consumption on the fields engineering research has not stopped at the improvement of power-generation. A study of balancing problems has given us the "pumping-power," the aim of which is no less than to reduce the cost of pumping wells to the nett cost of raising so much oil through so many feet of height in such and such a time. That ideal is still far from accomplishment, but already it has proved possible to cut down the power-consumption for pumping to a very considerable extent.

I should be guilty of a serious omission if I did not make more specific mention, than I have as yet done, of the application of electrical energy to oilfields activities. Probably the most important installation of plant for the generation of this form of power specially for oilfields purposes, and for these alone, is that which supplies current to the Yenangyoung and Singu Fields in Upper Burma. The power station output amounts to over 40,000,000 units per annum, and a considerable proportion is carried over a transmission line about forty-three miles long to the Northern field. The initial installation was originated and designed by the late Mr. C. H. McCarthy Jones, and was brought into being and developed by the late Mr. W. S. Toplis. The whole scheme has been so fully described in Mr. McCarthy Jones' paper read to this Institution in February, 1924, and in Mr. Toplis' paper to the Second International Drilling Congress recorded in the current number of the Journal, pages 591 to 610, that I need not enter into any detail, and will simply refer you to these papers.

The design and laying of a pipeline and its attendant pump stations is particularly the province of the engineer, and frequently involves problems of great interest. Where the line must cross wide areas of desert the work may assume huge proportions, requiring the provision of an expensive transport system for the moving of material and for the maintenance of the pipe-laying gangs. The actual ditching has been simplified and expedited by the introduction of specially designed machinery, but this method cannot

always or in every case be applied, and much of the work must still remain of a laborious and difficult nature. The investigation of the available routes for a pipeline and the final survey of the route chosen are matters of great interest, as are the questions of allowances for rise and fall of contour when estimating the capacity of the proposed line. One very important factor in the calculation of the capacity is the viscosity of the oil to be pumped and carried. In one line in which I was concerned it was found on completion that possible throughput was higher than my calculation. I have always been of opinion that syphonic action had some effect and that the oil was actually less viscous in bulk than the samples had indicated. There is no room for mistakes in pipeline work as the running expenses are continuous, and every fraction of a penny of increase in pumping costs means so much less profit on the sale of the products. And if the design and construction of a pipeline are engineering matters entirely, so also are its operation and maintenance.

We have now followed the course of crude petroleum history from its earliest stage to the end of the pipeline, which normally emerges in the refinery. I fear that so much time has been spent on the field that the refinery must be dealt with rather rapidly and in outline rather than in detail. I have deliberately discussed the engineer's services on the fields at some length, as they are there probably less understood and recognized than in the refinery where, to use American-English, they stick out a yard. There are few keener pleasures than to be asked to examine a site and to be commissioned to lay out to best advantage upon that site an oil refinery or another industrial undertaking of like nature. It has been my thrill to receive such instructions on quite a number of occasions.

As a means of conveying a good general impression of the completeness with which the design of an oil refinery lies in the engineer's hands, you will pardon me if I describe the method I have used—I presume a method used by many—for scheming such a layout. Sometimes I was given an entirely free hand, sometimes I had to take into consideration the view of others. I need not say which condition was more to my liking.

At times there was a clear site to work upon; at other times the site was occupied by existing works which had to be kept going. The former condition was the easier, the latter the more interesting because the more difficult. The first steps were to examine the site carefully—personally, if possible, otherwise by proxy—to survey it accurately and to ascertain its levels relative to its surroundings, especially relative to any existing road or railway, to any canal or waterway which might prove useful as means of access.

Upon a site plan, plotted from the results of such a survey, special record was made of any notable variations in contour, in view not only of the obvious importance of so disposing the various units of plant as to take full advantage of gravity for transfer of oils in process, but also of the cost of earthwork. It is not always realised that excavation and earth-filling, apparently such simple operations and carried out by the cheapest class of labour available, may yet entail serious expenditure unless experience and foresight are brought fully to bear upon their direction. Perhaps I may be permitted to recall in this connection an unfortunate experience of an engineer friend who, in the course of an important scheme, arranged that two level sites upon a fairly steep hillside should be formed by excavation in the one case and filling with the recovered spoil in the other. The engineer concerned—a young man at the time—overlooked the very notable increase in bulk of the material disturbed, and on completion of the operation was left with an enormous surplus of spoil, the disposal of which formed a very embarrassing problem.

As the next step, the principal sections of the refinery plant—benches of stills, batteries of boilers, paraffin chilling plant, sweating plant, lubricating oil distillation plant, candle factory, cracking plant, power station, central offices, workshops, stores, etc., were designed in outline as separate units; any special requirements of that section in the direction of power supply, water service, and the like were noted, and the approximate over-all dimensions were determined.

The final stage was reached, as a rule after consideration and discarding of many alternatives, by the assembly of the blocks of plant—I am tempted to use the analogy of the "jig-saw" puzzle—within the demarcated and contoured site plan in such a way as to reconcile the frequently conflicting requirements of the various units for preferential treatment in regard to contiguity to power or other services, and always with full regard to continuity of movement and elimination of all avoidable handling of materials in process.

One very important point must be kept prominently in view—the possibility and probability of extension. Fortunately in many ways, though unfortunately for the designer, no oil interest knows beforehand the ultimate limit of expansion. A case in point will illustrate. The Abadan refinery in Persia was originally designed to deal with 2,500,000 gallons of crude oil per month. Before the plant had been completely constructed at home, and long before completion of erection in Persia, instructions were issued to raise the capacity to 5,000,000 gallons, and again, while the construction engineers were dealing with this extension, orders

were given to increase to 8,000,000 gallons. I ventured to point out to the directors that this kaleidoscopic method of building a refinery was very apt to confuse the men who were responsible for erection. Thanks to the good work put in by these men, no injurious result followed, and the extension of this refinery has gone forward by leaps and bounds until its capacity is within measurable distance of 100,000,000 gallons per month. How could anyone foresee and allow for a 4,000 per cent. increase within twenty years? In planning a refinery due regard should be had to the amenity of neighbours, if any, or possible neighbours, in the future. There are sections of the plant which should be kept as far as possible from boundaries for fire risk reasons, and there are sections in regard to which the direction of the prevailing wind should be studied.

Engineering developments have been no less important in the refinery than on the field. Apart from the obvious advantages of electric power for driving refinery plant, one of the most striking features of present-day practice is the widespread adoption of tube-stills. Steam engineers have long appreciated the importance of rapid circulation as a means to efficiency in heat transmission, but only during the last fifteen years has the value of radiant-heat transmission been generally realised. These two principles, promptly applied to the design of water-tube boilers, have been extended to the design of tube-stills which are now regularly and safely run at thermal efficiencies of round about 80 per cent. By applying the principles of heat-exchange, so long exemplified in the familiar exhaust-steam feed-water heater, the total heat consumption for the fractionation operation—still the most important of the refinery processes—has been cut down to a figure that fifteen years ago would have seemed impossible of attainment.

A rather curious point has arisen in some cases from the development just described. As is well known, some degree of cracking was for long regarded as an inevitable concomitant of the process of distillation as carried out in the usual type of shell still; this cracking was regarded as an evil only to be mitigated by the use of large proportions of injected steam or, alternatively, by operation at reduced pressure. Fears were expressed, among refiners, that the high furnace temperatures employed in pipe stills, as perhaps the most potent factor for improving heat-transfer efficiency, would increase the extent of that cracking. As is now well known, the reverse is actually the case. Chemical research, between which and engineering science there are mutual debts of obligation which can hardly be over-estimated, has recently shown the importance of the time factor in cracking; by increasing to a

great extent the speed of circulation through tube stills the effect of the time factor has been so far cut down that the fractionated products bear far less traces of the effect of partial cracking than those from the older type of apparatus.

If in regard to distillation and fractionation the engineer has led the chemist, in the field of cracking he must take second place; it is, however, a very good second. The problems set by the chemist to the engineer have been met with remarkable success; so much so that the construction of large vessels to withstand the most onerous conditions of temperature and pressure has now become almost a commonplace matter. Nevertheless it is felt in many directions that the engineer has not said his last word on the subject of cracking plants, and that these problems, so successfully countered up to the present by the construction of these colossal reaction chambers and the like, would be better met by avoidance of the necessity for such containers.

I have spoken earlier of the punishment of metal in certain drilling services; in presence of the reaction chamber I feel as if metal were undergoing torture. I have, as we all have, a high regard for these uncomplaining servants of humanity, the nobler metals, and here I do not mean gold and silver; and to raise a welded steel vessel to a red heat one day and to cool to atmospheric temperature the next, and to continue this process for years seems to me an outrage to be discarded so soon as research will permit.

In the direction of oil refining the last five years have seen the successful development—as a joint accomplishment of the engineer and the chemist—of the *in situ* process for regeneration of filtering earths. This matter can only be touched upon very briefly here, but it may be said that the old processes, which involved either the discarding of large quantities of spent filtering medium or costly and wasteful regeneration of that material by roasting, have been abandoned in some refineries in favour of a system of regeneration which is eminently controllable and to some extent self-fueling; a system, moreover, which minimises the consumption and waste of filtering earth.

The extraction and refining of paraffin wax remains to-day substantially in the state in which they were left by Norman Henderson forty years ago. Wax distillate is still chilled and pressed, and scale is still sweated in some form of apparatus to produce finished wax. Detail improvements have been made in the design of coolers of greatly increased heat-transfer efficiency; of presses of large capacity and long life; and of self-contained sweating stoves designed to give improved control and to avoid the necessity for the old "messy" use of water for flotation. The essentials of the process, however, remain the same, and there is here a large

field for the engineer to work upon. It is true that promising developments are in progress in the direction of centrifugal separation of wax, but up to the present these only provide a partial and by no means a generally applicable solution of the problem.

I should have failed to make use of material lying very readily to my hand if I omitted mention of, and grateful reference to, Dr. Dunstan's Cantor Lectures of January, 1928, delivered in this hall to the Royal Society of Arts. The course of three lectures was entitled "Scientific Foundations of the Refining of Petroleum," and formed not only a liberal education in the subject dealt with, but a literary treat in the lucidity of the language used. The illustrations in the published form—lantern slides in delivery—go far to prove the all-pervading influence of the engineer and engineering practice in modern refinery methods.

As a result of refinery processes, the original crude oil becomes marketable products of liquid or solid form. These must be stored and eventually carried to the centres of population whence their distribution is most convenient. It is inevitable that they be handled in bulk or in small containers and conveyed over sea or land. Some of them are dangerous and must be treated with the care due to highly inflammable material. Some of them are pumped away from the refinery; some are carried on road or on rail: not one of them can be handled without recourse to the engineer's services. The road is made by him, the rails are laid by him, the tanks of large capacity and the containers of smaller, are his production. It is worth while considering for a moment in passing, the highly specialised industry of the tinplate container, say the four-gallon tin of the East. The arguments around single and double seaming, the constant modification of form to reduce liability to damage, the saving of a fraction of an ounce of solder per tin completed, the design of the stamping machines, nay, the production of the tinplate itself, are all cogs in the great wheel, and each one of them is the overwhelming interest in one man's or another man's life. Upon one occasion I had an unhappy passage from Calcutta to Rangoon; on the same ship was an expert on tin making. For two days we argued single-seam versus double-seam, and the time passed more rapidly than my recumbent position would suggest. It is said that the secondhand four-gallon tin is replacing the earthenware chatty of the East, and I can vouch for having seen in the native market in Karachi ice cream sold from such a container. I have had unusual opportunity of becoming acquainted with the plant for the production of tinplate and with the processes between the sheet bar and the finished plate, and in this accessory to oil lies a whole history of highly specialised engineering practice.

If material is handled over a wharf on its way to the tanker or other ocean vessel that wharf owes its design and construction to an engineer. The wharf is probably fitted with a crane or a conveyor or another means of rapid handling. All these are the outcome of engineering design and practice.

When we come to regard the Tanker herself we are in the presence of one of the highest developments of engineering skill. Than the Naval Architect there is no finer engineer. To those who have been privileged, as I have been, to pass their youth in a shipbuilding port, the beauty of form of the ocean-going vessel, the suggestion of power in the stern lines of the battleship, the glory of a *Britannia* or a *Shamrock* in full sail before a fine breeze, need only to be mentioned to bring due appreciation. And if the engineer-designer of the tanker must be included in our wide-flung army of supporters of the oil industry, what about those who control the driving mechanism of these vessels? I cannot do better than refer you to McAndrews' Hymn as an expression finer than anything I can write of my regard for the sea-going engineer. And to the few who know not that epic or idyll of steam, I would recommend an early amendment of that omission. You will find it in Kipling's "Seven Seas," not far removed from "The Liner, she's a Lady." On more prosaic and practical lines I would mention as one among others that splendid service of tankers which has been so aptly named by Lord Greenway "the extended pipe line," and which moves oil from Persia to this country in enormous volume and with unfailing regularity.

Beyond the bulk transit there lie the larger and smaller depots of distribution, controlled and operated by engineers, whose services include pumping, storing, it may be tin-making, measuring, filling, and all the multifarious operations of such traffic. The motor lorry, the road tank wagon, the rail tank wagon, all enter the service, and are all designed, constructed, operated and repaired by engineers.

An entirely new industry has been developed in the design and manufacture of the kerbside pump for distribution of petrol. The necessity for accurate measurement, and for continuing accuracy of measurement, the desirability of making readily evident to the customer that he has received his due quantity, have put to the test the finer qualities of the engineer of precision. Beyond this he must make his apparatus foolproof, and what is probably more difficult still, he must make the outfit rogue-proof.

And now it may be thought that the series of relationships is ended as we have traced the connection from the prospecting stage to the storeroom of the user. But we have only opened a new chapter, the chapter of application and use. I do not propose to

enter largely into this domain of application, but in another sense than that used earlier in this paper, it is not too much to say that without the engineer the oil industry as we understand it to-day would be practically non-existent, since the truly remarkable expansion of markets and the no less notable manner in which production and refining processes have kept pace with that expansion, are almost entirely traceable to the invention and perfection of the internal-combustion engine.

And still further must we go. The Oil Industry has become a service institution in that its specialised knowledge of its products and of their most satisfactory use has been placed at the disposal of every buyer of these products. To-day the Oil Industry finds itself in the position of being not merely the druggist who produces the medicine but also the physician who prescribes the manner in which it should be used. We recognise now that our work is not finished when we have sold our products, but that we must be prepared to help our customer to get the last possible "therm" out of his purchase.

It may have been observed that reference to the services of the geologist terminated at the moment when oil entered the pipe line, and that the functions of the chemist did not appear till the oil left that line. The mention of the engineer has continued with irritating reiteration from beginning to end. Such, broadly speaking, are their relative positions in the story of oil winning, refining, distribution and use. And this is my case for the importance and ubiquity of the engineer in the Petroleum Industry.

There are still matters connected with this subject which are worthy of mention, and for the remarks which follow I am solely and completely responsible. Years ago a former member of this Institution told me that he had heard one of the directors of an important oil company—a man whose name is well known and highly regarded in the world of oil—express as his considered opinion the view that the technical side of the industry should become better represented on the directorate of the oil companies, through direct inclusion of technical members on these boards. That was fifteen years ago. Some progress has been made in the direction indicated, but we cannot call it marked progress; in fact, it has been painfully slow.

Of the value of such an inclusion there can be little question. It is but seldom that one meets a director or a member of an administrative staff who can grasp completely the details of a scheme, who can read a drawing, who understands the technical details of a specification. A general lay-out plan is difficult for him to follow, and a detail drawing becomes so many lines and a title. I am not suggesting anything in the nature of blameworthiness—it

is impossible for any man, however willing, to know all sides of so great an industry—but I am suggesting that if a man otherwise worthy to be a director and possessing the requisite technical knowledge were to examine schemes before submission to the administrative lay members of the board, his word would come with the added weight of one carrying a director's responsibility. In America and on the Continent the worthiness of the engineer to enter the directorate has been much more broadly recognised than in this country.

It is a serious difficulty for the directorate or administrative side justly to hold the balance between the technical side of engineering and the operative or purely mechanical. To illustrate my point I will assume a purely imaginary instance. It is possible to think of a layman director visiting an oilfield and being shown a steel derrick erected in record time. He naturally and justly compliments the mechanic who so erected it, but he has not before him the knowledge that the derrick could only be erected in record time because it was designed to be erected in record time. It was in the designer's room and on the drawing-board that the derrick was *first* erected in record time. It could have been so designed that no man on earth could have erected it in record time, but the designer knew the immense importance of quick handling, both in erection and in dismantling, and it was he alone who made it possible. It may be that he had to balance cost with ease in erection, that he had to sacrifice symmetry to the same desideratum, but it was in his hands that the design took shape with all these problems before him, and to him belongs the greater credit.

It is unnecessary to carry this fields illustration to other sections of the industry; it applies equally to the refinery, to transport and to distribution. It is very natural that the impression made upon the non-technical mind, by such completed structures as a fine engine-room, a power station, or a whole distillation plant, should be much greater than the effect of examining the designs which preceded all these, and without which the various constructions could not have come into being. It is natural, but it is very unfortunate for the designing side of engineering. It is in the designing room that the efficiency and service of any plant is sealed. A good design may suffer from slipshod or slovenly construction, but a bad design can never be made good though the work of construction be never so fine.

The supreme function of the highly trained technical man of long experience is so to apply his knowledge that the policy of trial and error—that degradation of true engineering—shall be eliminated, and that there be an end to the system which has been so aptly termed " Thinking in Steel," a method of thinking whose extravagance is beyond measure wasteful. It is not to be

thought that there is any difference of opinion in these matters as between the designing and the constructional sides; each knows its own value and duly respects the other.

I should desire before closing this paper to call the attention of those who may discuss it to the important question of the best method of educating and training engineers for the Oil Industry. I would not for a moment have Professor Nash think that I have forgotten his work at Birmingham University, nor have I overlooked the services of the John Cass Institute, but I have now in mind the scores of boys I have passed through my hands on their way to fields, refineries or distribution depots. It has been impossible for the greater number of these lads to have the advantages of Birmingham or other such training, and how best to suggest a line of education for them has been a serious puzzle to me as to others. Public school and University are beyond the resources of many and are the privilege of the few. The problem is how best to combine elementary education, higher technical training, and practical workshop training in the period which lies between childhood and say the age of twenty-two years.

I am entirely in favour of that practical workshop training; it gives a man a sense of team work and a knowledge of discipline that are of value throughout life. I should be indebted to the Members who may speak if this matter could be further dealt with. I regret that in the time available for preparing this paper I was unable to give to this question of education and training the consideration it deserves. I would suggest that the matter is not only worthy of a contribution to the Institution's records, but that it might form the subject for a symposium.

I have spoken of interviewing lads for appointments abroad. At such times I have felt the heavy responsibility of diverting the career of the accepted candidate from one channel to another. But I have never felt that in offering a boy a post in the Oil Industry I was directing him into a blind-alley occupation. There is nothing of the cul-de-sac in any branch of the petroleum industry; there is room there for the mightiest sinews and equally room for the finest brains, and there are never too many men available for the senior positions; in fact, there are seldom enough trained men to fill them.

If I am right in saying that the Petroleum Industry provides wide enough scope for the best effort that a man can put into it, then I am justified in calling attention as a final word to the natural corollary. If there is room for all, then let each, forgetting or putting aside any question of relative importance in the service, do his utmost to contribute his best in thought and effort, to that industry whose resources, where known and applied, have done so much to add to the comfort, convenience, and happiness of the human race.

DISCUSSION.

The President said that everyone would agree that they had listened to a dissertation immensely thoughtful, immensely appreciative and sympathetic, an effort by an enthusiast for the work on which his life had been spent. The Institution was particularly fortunate in having had put before it a long record of experience in the oil industry, and Mr. Gillespie was to be congratulated that, unlike so many eminent men, his monuments were with him to-day. It could be said, without waiting for the misfortune of his demise: "Here are the monuments of a great man!" The great refineries in Burma and Persia, for which he had done so much, were to-day standing as long-lasting monuments of his work.

In reading the definition of the engineer which the lecturer had extracted from the Oxford Dictionary, it had occurred to him that at last had come true the prophecies of Sir Boverton Redwood, who had set out many years ago to prove that the geologist and the chemist and the engineer in the petroleum industry really formed a specialised type of technician. What had been said that evening was not so much a dissertation on the engineer as on the petroleum technologist. He was at a loss sometimes to find out where the chemist's work ended and that of the engineer began. He thought it could be broadly stated that the beginning of the technical side of the industry started somewhere in a laboratory, and that the geo-physicist or the chemist or the physicist was the man whose particular aptitude was handling things on a small scale. When the method thus worked out appeared feasible, then came along the stage of development, where the embryo process was taken a stage further, and was made to function, again in a laboratory, on a few gallons or even a ton scale. When success was achieved there, the real final work of the engineer began; and he, after all, was a man of science who "thought big." It was all the same kind of science; it was all the same point of view; it was all the same method of work; but whereas the chemist or the physicist were workers in glass and in small apparatus, the engineer was a man of similar mentality working on a large scale. He took the author's paper as an extraordinarily good illustration of that point of view. They were all petroleum technologists, specialists, perhaps, in certain directions; but they had, in the last sixteen years, managed to get a coherence and a point of view that would have been thought incredible before the Institution was inaugurated.

He had been very much impressed by Mr. Gillespie's remarks on education, and he would ask Sir Frederick Black, who, he knew,

had that matter very much at heart, to be good enough to open the discussion.

Sir F. W. Black said he had hoped to say a few words on the paper, but he had not expected to have the honour of opening the discussion, because that honour should fall either to engineers, who agreed or disagreed with a distinguished member of their profession, or to geologists, who felt either that they had not had justice done to them or that the author had made a handsome acknowledgment of what they did, and similarly with regard to the chemist.

First of all, he was sure that all members would like to associate themselves with the fine tribute paid by the author to the late Mr. McCarthy Jones and the late Mr. W. S. Toplis. Mr. McCarthy Jones, it would be remembered, was a Redwood Medallist of the Institution.

At the beginning of the paper the author said he now found himself in a position of freedom; he did not say of less responsibility, though perhaps that was true also. Mr. Gillespie had pointed out that he was already feeling the advantage of standing, to some extent, outside the active sphere of work, and of watching others get on with it. He (the speaker) was sure that Mr. Gillespie would keep his knowledge of the literature of his profession, and although he would doubtless devote some of his time to other pleasing pursuits which he had hitherto had to neglect, it was to be hoped that the Institution might have the advantage, from time to time, of hearing some of the results of Mr. Gillespie's study from a more detached point of view.

He liked particularly one passage in the paper, where the author spoke of the way the geologist, when he was doing his preliminary work, kept in mind the engineer who was to follow him, because that was of the very essence of co-operation between different experts in the oil industry. There was a similar fine tribute to the chemist. At the one end of oil winning, etc., the author recognised how the geologist did a little of the engineer's work for him, and at the other, e.g., in the refinery, etc., how the chemist and the engineer were working together, recognising their mutual obligations.

The paper set forth some very valuable abstract principles. He did not mind telling the lecturer that an engineer had made this comment: "It is a little too abstract for me; I should have liked more detail"; but in fact the paper did contain a good deal of detailed technical matter.

Towards the end of the paper the author dealt with a subject on which a few words might be said, and that was the training of the

young engineer for the oil industry. The author suggested that the subject was big enough to be brought up again, and dealt with not by one man but by means of a symposium. The Institution had had a symposium of chemists a few weeks back, and after one man had put up a beautiful formula on the board the next came along and asked the President's permission to rub it out and put up another one. That had contributed a good deal of knowledge, and he hoped that Mr. Gillespie's symposium would do the same. To quote again his engineering friend, he had said he did not understand what Mr. Gillespie meant about passing young men through his hands who were not properly trained for their business, because the engineer, when he came to the oil company, ought to be already trained and fit to take up his job. He hoped Mr. Gillespie would find time to say a few more words on that subject. It certainly did seem that boys ought not to be coming to him expecting to become engineers in the oil industry unless they had had a certain amount of engineering training. It appeared from a certain expression in the paper as if Mr. Gillespie wanted to deal with the whole question of training from a very much earlier age than that at which the young engineer would normally come to him, whereas what he had specially in mind was perhaps that, given a case of a young man who had already had a certain amount of education, and had gone through the workshops and called himself an engineer, it was necessary to finish him off, so to speak, before he went abroad to the oilfields, by giving him special knowledge applicable to the petroleum industry. He suggested that that was perhaps what Mr. Gillespie had in mind, and in any case it was to be hoped that the idea would be further developed. He (the speaker) was interested in the subject very specially from the point of view of the Sir John Cass Institute, to which the author had referred, and because there was a great deal being said, and, of course, much being done, in the direction of finding for the young fellows as they came from the secondary schools a path to the University for those for whom the University course was going to be of special benefit, and a path to the technical college for those to whom that kind of training would be more particularly advantageous. He did not think that in the John Cass Institute, in their petroleum course, they had so far been able to do, on the strictly scientific and technical side, much more than devote themselves very specially to chemical training, with the direction of which Dr. Dunstan had a great deal to do, also Mr. Kewley Mr. McConnell Sanders and Professor Brame. That training had been of great value to men in the distribution branch of the industry; but so far, except in a very general way, in the course of lectures rather than practical work, the engineering side had hardly been

touched. Whether anything was possible was one of those questions which he hoped Mr. Gillespie would further develop.

He had recently read a speech by the late Minister of Education, Lord Eustace Percy, who had devoted himself earnestly to the question of technical training and who had made a special point of saying that he thought there was a great deal yet to be done in taking boys from the secondary schools, not only through the workshops but to the technical colleges.

He could not approach any of the matters dealt with in the paper from the point of the engineer strictly so called; but, following the definition of the man "who overcame difficulties," and as one who had for many years worked in active co-operation with engineers, he supposed he had had some little experience of engineering matters in a general way. He had looked up Kipling's "MacAndrews Hymn," referred to in the paper. If the author had come to him for a title for his paper he would have suggested "John Gillespie's Hymn," because the paper was a magnificent prose hymn. The lecturer said he had not attempted to deal with his subject in an academic style; but he had done far better than that. When a man understood his subject, and loved it, and had been an adornment of his profession, and had thrown himself heart and soul into it, if he sat down with any knowledge of writing at all he would produce, as Mr. Gillespie had done, a fine piece of prose, even on a technical subject.

The author had mentioned that he was a Scot. The paper should have been headed "John Gillespie's Hymn," and underneath, "I am a Scot." He (the speaker) used to read an author, not now perhaps so widely read as he was some years ago, viz., Thomas Carlyle, a Scot who preached the same gospel of enthusiasm for one's work which was to be found in every line of Mr. Gillespie's paper.

He hoped Mr. Gillespie would continue to give the Institution the benefit of his ideas. All members would wish him, with his "armour put off," as he phrased it, many years of happiness and energy, and a vigour to prosecute a detached interest at least in his old profession, and more intimately perhaps in other congenial pursuits as well.

Mr. E. R. Redgrove said he had not expected to be called upon to contribute to the discussion of the paper, which he felt was so good as to be altogether above him. He regarded it partly as a technical paper, but more especially as a masterly treatise that could have been written only by a man of Mr. Gillespie's experience and knowledge. The author himself had ascended to the topmost peak, and from that point of vantage had viewed the whole of the

petroleum profession, leaving out nothing. The education of the young engineer and technologist was carefully considered and then the reader was taken through the work they did when they became proficient. Finally there was the very important suggestion that in the administrative direction of all companies the technologist should find a place. His own experience was that business men, keen as they were in finance and accountancy, were most frequently unappreciative of the problems attached to the technical side of the business, and it was an excellent idea that technical men should be included on the boards of all companies. It was an idea which was growing at present, and which, he hoped, in the future would be recognised in every branch of industry.

The President had given an inkling that the part played by the chemist was rather more than an odd bit of that odd 15 per cent. He did not want to stress the point too far, but, as a chemist, he did feel that the chemists were left a little in the background, for where would the engineer be without the chemist and the metallurgist? The engineer might, and did, have wonderful ideas; he visualised wonderful bits of machinery that would do wonderful work; but these ideas could never be brought to fruition without the chemist and the metallurgist who produced for him the material with which he worked.

The paper had given much food for thought. It had delighted him; and he hoped the few words he had contributed to the discussion threw no shadow of disparagement upon the paramount importance of the work done for the industry by the engineer.

Mr. C. E. Capito said it was difficult to discuss such a full paper without drawing from personal experience. He knew of one prospective oil field where the original road in was made to follow a bridle track with very steep grades, lorries could only get through with half loads and with the aid of men to push them up the steeper grades. Later an engineer was sent along and by diverting the road round some of the hills or by developing so reduced the grades, at comparatively small cost, that lorries could get up on their own power with almost full loads thereby reducing transport costs and, incidentally, those of road maintenance.

With regard to the education of engineers, he could only speak of oilfield requirements where they could be divided into two categories, viz., the Mechanic and the Petroleum Engineer. The former, who is essential for the good running of the machinery and repairs to tools, etc., must have workshop training and experience with, if possible, night classes on the theory of their work. For the latter a University or Technical College training was essential which, in his opinion, should be made as broad as possible as,

later on, these engineers are often left alone on an outfield where they may have to be their own civil, mechanical and electrical engineer for repair and maintenance work. In addition they should have a working knowledge of petroleum, geology and chemistry. With such an education they are able to have an understanding when dealing with the work of such experts as civil and other engineers, geologists, etc. He did not wish these remarks to be taken as a criticism of any petroleum course.

Mr. B. J. Ellis said he agreed entirely with the views expressed by the author. There was only one point he desired to mention, and that was with regard to the Institution. The Institution itself had, so far, concentrated to a very large extent on the theoretical or very technical side, and particularly on the chemical side, of the oil industry. It had not gone in to anything like the extent of the American Petroleum Institute for the practical engineering side of things, and he thought that very much more could be done in that way by the Institution. The American Petroleum Institute were getting out a large number of standards for all types of drilling machinery and they went quite deeply into latest field methods and refining processes at their various meetings; but in the British Institution they had done very little in that way. Papers were read at that Institution which were, no doubt, very valuable; but there was not otherwise that assistance to the industry as a whole, and especially to the practical side of it, which might be given.

Mr. Gillespie (in reply) cordially thanked Sir Frederick Black for his most appreciative references to the paper and to himself. Sir Frederick and he had been friends for many years, and Sir Frederick had always been very kind to him, though never more so than that night. He was afraid he was unable to discuss further and without fuller consideration the question of education. Sir Frederick had suggested that he had in some instances dealt with boys who had had no training whatever. That was not quite the case. One of the greatest difficulties was the diversity of training that made itself evident during examination of candidates. Boys came from all classes and with all types of education. For the boys he had chiefly to deal with, the age of 22 or 23 years was the best possible time for them engaging for the East, in view of health conditions and acclimatisation, and it could not be expected that a boy of 22 should have all the technical training that might be desired, or suggested, by Mr. Capito; he could not acquire it in the time. What he was after was for some of those interested in the matter to get together and think out some reasonable standard

and method of education for recommendation to youths who aspired to a career in the oil world. He himself, of course, was now outside the industry, and no longer able to deal with the question in any practical way.

With regard to the question of the chemist being of more value than part of the 15 per cent., he would remind members that the 15 per cent. was not his. He felt inclined to shelter himself behind Dr. Dunstan's excellent suggestion, that members were a group of technologists rather than that they belonged to three separate categories.

As to Mr. Ellis's criticism of the Institution, he would leave that to the President to deal with. He thanked him for his remarks about the paper, but he must not forget that he was part author.

On the motion of the President, a vote of thanks to the author was accorded with acclamation.

Decomposition of Paraffin Wax on Heating.—II.*

By H. I. Waterman, J. N. J. Perquin and H. A. van Westen.

The application of thermodynamical data on the reactions of pyrolysis has recently received more attention. The work of Francis, who has derived equations for the free energies of formation of different hydrocarbons and alcohols as functions of temperature[1], may be especially considered. More than ever it will be necessary to collect accurate experimental data in connection with the pyrolysis of hydrocarbons. Thus the theoretical predictions may be tested and, on the other hand, new predictions about unknown processes may be worked out.

The investigations on the thermal decomposition of paraffin wax at high pressure, which we have carried out during a period of about ten years, have now been extended to ordinary pressures. Special attention was given to the decomposition which occurs at the relatively low temperatures of 327–385°. The work was rather difficult because the methods of analytical investigation used in practice had to be improved. The determination of unsaturated hydrocarbons had to be carefully studied, giving special attention to the behaviour towards bromine. It was necessary to prepare different olefins, diolefins and other hydrocarbons in a pure state, and it was soon found that even the best preparations from literature such as pentene, decylene, hexadecene, isoprene[2] did not answer the expectations. Pinene[2] had already been prepared in a pure state. This part of our work could be carried out by our method for the determination of the hydrogen value of unsaturated compounds.[3]

The ordinary analytical methods for gas-analysis also proved to be not very accurate and in many cases were very unreliable. Therefore improved methods had to be worked out[4].

In a preceding paper[5] the method of determination of molecular weight by Rast, determining the lowering of melting point of camphor, was further investigated and improved.

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* Paper received December 7, 1929.

[1] A. W. Francis, *Ind. Eng. Chem.*, 1928, **20**, 277, 283.

[2] *Rec. trav. chim.*, 1929, **48**, 612, 637, 1084, 1097, 1103, 1191.

[3] *J.S.C.I.*, 1928, **47**, 363T; 1929, **48**, 51T.

[4] *Die Analyse der Gase technischer Hydrierungsprozesse, Chem. Techn. Teil von Erdöl und Teer, Heft* 38 (Nov. 19, 1925), Heft 39 (Nov. 26, 1925); *Chem. Weekblad*, 1927, **24**, 321.

[5] "Decomposition of Paraffin Wax on Heating," *Journ. Inst. Petr. Techn.*, 1928, **14**, 318.

It was pointed out that paraffin wax at temperatures up to 370° is relatively thermoresistant. Heating for 10 hr. at 370° leads to a lowering in average molecular weight of 410 to 360, while the gases which developed, as well as the low-boiling distillate and the residues, contain unsaturated hydrocarbons. Heating during a number of hours at 327° and 340° gives hardly any change. The development of gas is small, whereas the setting-point of the residue is lowered by 1°.

The following experiment (No. VIII.) was carried out in the same manner, only the temperature was higher, *viz.*, 385° C. The original material consisted of 90·0 g. Rangoon paraffin, freed from air in the usual way, while the apparatus was filled with CO_2 instead of nitrogen as in former experiments. The carbon-dioxide was condensed in one of the vessels, cooled in liquid air, and the remaining gases pumped off. Then the apparatus was filled again by allowing the solid carbon-dioxide to evaporate; part of the apparatus, namely between cocks P and E remained evacuated and was used as a reserve space for catching the developed gas. At the end of each experiment the gas was separated into two portions and, as one of the vessels was cooled in liquid air and the remaining gas pumped off, hydrogen was accumulated in this first portion. The condensate, consisting of CO_2, lower hydrocarbons and light gasoline was distilled to vessel CC[6] by cooling this vessel with liquid air and surrounding the vessel which contained the condensate with water at room-temperature. Then the temperature of CC was allowed to rise to 20° C., causing the carbon dioxide and the lower hydrocarbons to evaporate. These gases were transferred to another vessel, once more evaporated, measured and analysed. In CC only light gasoline remained, which is henceforth indicated as "distillate No. 1." The weight of this distillate (1) was determined. The uncondensed gas, in which hydrogen is accumulated, consisted of 18·5 c.c. hydrogen and 62·3 c.c. methane. The total formed was 501·2 c.c. gas (0°, 760 mm.), consisting of 18·5 c.c. hydrogen, 62·3 c.c. methane, 167·1 c.c. unsaturated hydrocarbons, 253·3 c.c. saturated hydrocarbons of the formula C_nH_{2n+2}; here n amounted to 2·94, while n of the unsaturated hydrocarbons C_nH_{2n} was 2·68. In this experiment, after a *heating period of seven hours* at 385° C., 2·07 g. light distillate (1) and 13·90 g. heavy distillate (2) were formed and the latter remained in the receiver of the distillation flask. Both products were liquid at ordinary temperature. The weight of the gas, calculated from the composition, is 0·81 g. (see the table), of the residue 73·00 g., a total of 89·78 g., so that there is a loss of about 0·2 g. The residue

[6] A transportable vessel furnished with a cock (see former paper *l.c.*).

had a molecular weight, according to Rast's method, of 452, 452, 457 ; this high value must be ascribed to the fact that at the higher temperature a larger quantity of the lower fractions was distilled off. The spec. grav. 70°/4° of the residue was 0·7792, the bromine value (addition). 3·5–3·7, while the setting-point according to Shukoff was 51·9°. The bromine values (addition) of distillate (1) and distillate (2) were 105·5–107·7 and 44·4–45·6 respectively. The important fact of this experiment is that hydrogen is definitely shown to be present; now it was desirable to know if this formation of hydrogen had taken place at lower temperatures. The following experiment (IX.) was carried out at 360° C. during twenty-five hours at intervals. In the first pumped gas hydrogen was without doubt shown to be present, as in 31·3 c.c. of this gas 4·7 c.c. hydrogen were determined.

BALANCE OF EXPERIMENT VIII. : 90·0 g. PARAFFIN WAX.

501·2 c.c.	18·5 c.c. H_2	0·00 g.	0·81 g. gas
	62·3 c.c. CH_4..	0·04 g.	
	253·3 c.c. homologues of methane (C_nH_{2n+2}), n=2·94	0·49 g.	
	167·1 c.c. unsaturated hydrocarbons (C_nH_{2n}), n=2·68	0·28 g.	
	2·07 g. distillate (1)	2·07 g.	
	13·90 g. distillate (2)	13·90 g.	
	73·00 g. residue	73·00 g.	
	Total	89·78 g.	

The volumetric composition of the gas was : 3·7% H_2
12·4% CH_4
50·6% CH_4—homol.
33·3% unsaturated hydrocarbons
100·0%

After heating 90·0 g. of paraffin wax for seven hours at 385° there were formed quantities of unsaturated gaseous, liquid and solid hydrocarbons equivalent to somewhat more than 12 g. of bromine : gases 1·23, distillate (1) 2·21 (*i.e.*, $2{\cdot}07 \times \frac{106{\cdot}6}{100}$), distillate (2) 6·25 (*i.e.*, $13{\cdot}9 \times \frac{45{\cdot}0}{100}$), residue 2·63 (*i.e.*, $73 \times \frac{3{\cdot}6}{100}$).

Some experiments have now been carried out in which paraffin wax was heated at 360°C. at atmospheric pressure during several periods of six hours (experiment X). After each period the balance was made up, the gas-analysis was carried out and the bromine-numbers of the light distillate (1), the heavy distillate (2) and the residue were determined. The original material consisted of 90·0 grs. of paraffin wax.

After the first period there remained 88·68 g. residue, and the second period was started with 87·31 g. of this residue. Of

this there remained after the second period 83·47 g. For the third period 79·40 g. of this residue were used, of which finally 77·10 g. were left.

The results of the analysis are thus not directly comparable, because they bear upon a quantity of substance which is somewhat smaller every time. However, the differences are relatively small so that it was not necessary for a first comparison to calculate all quantities in percentages. The balances of the first, second and third period are given in the table.

The analysis of the gases in the experiments was carried out in the following way.

Two gases were analysed separately, named gas I and gas II. Gas I is the gas which is pumped off *via* the vessel cooled in liquid air ; this consisted mainly of hydrogen and methane. Hydrogen was determined by fractionated combustion with copper oxide, the remaining gas combusted at a higher temperature. Gas II. is the gas, consisting mainly of lower hydrocarbons, obtained by evaporation at ordinary temperature and pressure from the mixture of hydrocarbons remaining in the cooled vessel.

With this gas there was carried out :

First, a total combustion followed by determination of the carbon dioxide formed. Second, a determination of the higher olefins by treating with 87 per cent. H_2SO_4 (method of H. Tropsch and A. Philippovich[9]) ; the remaining gas was treated with bromine-water to absorb ethylene and the resultant saturated hydrocarbons combusted by passing over red-hot copper-oxide.

Balances of Unsaturation.—The determination of the bromine values gave an insight into the increase in unsaturation of the reaction products as a result of the heat-treatment. It is seen that during the first period a quantity of unsaturated hydrocarbons is formed which is equivalent to 2·72 g. of bromine, in the second period the unsaturation has increased with 2·46 g., and in the third period with 2·16 g. It should be noted here that the gases and the distillates were expelled from the heating-zone and were not further subjected to heat-treatment. Finally, it has been shown that the unsaturated compounds, which form the origin of the bromine value, really possess the unsaturation represented by the determined bromine number. This is true for the light distillate. The light distillates resulting from the three periods were added to the light distillate from Experiment IX, in which paraffin wax was heated at 360°C. during 25 hours. The mixture had a bromine

[9] *Brennstoff-chem.*, 1923, **4**, 147.

		1st period (6 hrs. at 360°C.).			2nd perio		
Quantity of material used		90·0 g.			87·31 g. resid		
Hydrogen	64·6 c.c.	2·0 c.c.	0·00 g.	91·0 c.c.	2·2 c.c.		
Methane		9·7 c.c.[7]	0·01 g.		9·7 c.c.[8]		
Methane homologues		39·5 c.c. (C_nH_{2n+2}) ($n=3·0$)	0·08 g.		42·7 c.c. ($n=$		
Ethylene		3·1 c.c.	0·00 g.		15·0 c.c.		
Higher unsaturated hydrocarbons ..		10·3 c.c. C_nH_{2n}	0·02 g.		21·4 c.c. ($n=$		
			0·11 g.				
			Bromine value.				
Light distillate (1) ..		0·75 g.	75·8		1·40 g.		
Heavy distillate (2) (in receiver) ..		0·46 g.	41·1		2·27 g.		
Residue		88·68 g.	2·1		83·47 g.		
Gas		0·11 g.	96 (calc.)		0·15 g.		
		90·00 g.			87·29 g.		

[7] The average number of carbon atoms n was somewhat higher than 1 (1·2).

			87·31 g. residue of 1st period	
	0·00 g.		2·2 c.c.	0·00 g.
	0·01 g.		9·7 c.c.[a]	0·01 g.
$(n+2)$	0·08 g.	91·0 c.c.	42·7 c.c. (n = 3·0)	0·08 g.
3·0)				
	0·00 g.		15·0 c.c.	0·02 g.
	0·02 g.		21·4 c.c. (n = ±3)	0·04 g.
	0·11 g.			0·15 g.
	Bromine value.			Bromine v
	75·8		1·40 g.	83·1
	41·1		2·27 g.	36·4
	2·1		83·47 g.	2·4
	96 (calc.)		0·15 g.	173 (cal
			87·29 g.	

was somewhat higher than 1 (1·2).

[a] Here n

1 (6 hrs.).			3rd period (6 hrs.).	
ue of 1st period.			79·40 g. residue of 2nd period.	
0·00 g.			2·5 c.c.	0·00 g.
0·01 g.			6·9 c.c.	0·01 g.
3·0) 0·08 g.	69·3 c.c.		38·8 c.c. (n = 2, 7)	0·07 g.
0·02 g.			9·2 c.c.	0·01 g.
±3) 0·04 g.			11·9 c.c. (n = ±3)	0·02 g.
0·15 g.				0·11 g.
Bromine value.				Bromine value.
83·1			0·73 g.	85·3
36·4			1·37 g.	39·1
2·4			77·10 g.	3·4
173 (calc.)			0·11 g.	137 (calc.)
			79·31 g.	

[a] Here n was 1·3.

number 61·7[10]. A determination of the hydrogen value with 0·6743 g. gave a consumption of 57·6 c.c. hydrogen (0°760mm.) which agrees with a bromine value of 60·9; the bromine value of the reaction product was 0·1.

Summary.

In the pyrogenic decomposition of Rangoon paraffin, hydrogen is already formed at 360°C. and also at 385°C.

The gases formed at 385°C. contain a large quantity of unsaturated hydrocarbons.

After heating 90·0 g. of paraffin wax for 7 hours at 385° there were formed quantities of unsaturated gaseous, liquid and solid hydrocarbons equivalent to somewhat more than 12 g. of bromine.

Ninety grams of paraffin wax were heated at 360° during several periods of 6 hours. During the first period a quantity of unsaturated hydrocarbons was formed, equivalent to 2·72 g. of bromine, in the second period the unsaturation had increased with 2·46 g. of bromine and in the third period with 2·16 g. of bromine. The gases and the distillates were expelled from the heating-zone and were not further subjected to heat-treatment.

It has been shown that the unsaturated compounds formed, which are characterized by the bromine value, really possess the unsaturation represented by the bromine number determined.

A mixture of several light distillates of experiments at 360° had a bromine number of 61·7. A determination of the hydrogen value gave a consumption which agreed with a bromine value of 60·9; the bromine value of the hydrogenation product was 0·1.

Delft, Laboratory for Chemical Technology
of the Technical University.

[10] This bromine value is relatively small, which must be ascribed to evaporation-loss, especially with the light distillate from Experiment IX., which had been kept for a long time.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

RUMANIAN BRANCH.

Third Annual Report.

The Committee have pleasure in presenting their third Annual Report for the year ending October 25th, 1929, together with the accounts to that date :—

REVENUE ACCOUNT FOR THE YEAR ENDING OCTOBER 25TH, 1929.

		Lei.
RECEIPTS—Balance on hand as at October 15th, 1928		9,131.00
To Grants received from the Institution of Petroleum Technologists, London :—		
£27 @ 818 Lei		22,086.00
£9 @ 817.5 Lei		7,357.50
Total	Lei	38,574.50
EXPENDITURES—		
Postage		5,110.00
Expense of Reporter at Meetings		4,050.00
Printing and Stationery		400.00
Miscellaneous expenses		10,960.00
		20,520.00
October 15th, 1929. Balance on hand		18,054.50
Total	Lei	38,574.50

We have verified the above Receipts and Payments Account with the Books, Records, Vouchers, and other Documents of the Rumanian Branch of the Institution, and having obtained all the information and explanations we have required, we are of the opinion that such account is properly drawn up to represent a true and correct statement of the Receipts and Payments for the period under review.

A. L. HOFFMAN.
C. R. BRASIER.

The following is a list of members showing in the Branch Register :

Honorary Member	1
Members	48
Associate Members	14
Students	4
Associate	1
	68

The average attendance of members and non-members at the meetings for the year was 64.

Eight General Meetings of the Branch were held during the year ending October 25th, 1929, and the following papers read and discussed.

THE FOURTEENTH GENERAL MEETING AND SECOND ANNUAL GENERAL MEETING, October 26th, 1928. The Annual Report by the Committee was adopted. Following, a paper was read by Mr. S. F. Shaw, "Gas Lift Operations in the Seminole Field."

THE FIFTEENTH GENERAL MEETING, January 25th, 1929. "Safety and Economical Rotary Installations," by J. W. Elder.

THE SIXTEENTH GENERAL MEETING, March 1st, 1929. "Repressuring of Oil Sands," by Gwyn Elias, B.Sc.

THE SEVENTEENTH GENERAL MEETING, April 19th, 1929. "Crooked Hole from the Drillers Standpoint," by G. T. Chupp.

THE EIGHTEENTH GENERAL MEETING, May 3rd, 1929. Open discussion on "Electrification of the Oilfields," "Electrical Power *versus* Steam Power for Rotary Drilling," and "Automatic Feed for Rotary Drilling."

THE NINETEENTH GENERAL MEETING, May 31st, 1929. "Deep Well Pumping," by J. J. Honegger.

THE TWENTIETH GENERAL MEETING, June 28th, 1929. "Electrical Methods of Prospecting for Oil," by Dr. K. Sunberg.

THE TWENTY-FIRST GENERAL MEETING, September 27th, 1929. "Oil Well Pumping in Rumania," by J. J. Honegger.

THE SECOND ANNUAL DINNER of the "Rumanian Branch" was held on November 30th, 1929, at the "Clubul Industrial şi Internaţional," and was well attended by members and their friends. The Chair was taken by Captain J. E. Treacy.

The COMMITTEE for the year were: *Captain T. S. Masterson, D.S.O., F. W. Penny, Ion Edeleanu, J. A. Chaillet, Frank Russell, J. M. Walsh,* and *Captain J. E. Treacy* (*Hon. Secretary*).

The Committee wish to thank the Clubul Industrial şi Internaţional for the use of the Club for the meetings, and also wish to express their appreciation and thanks to Mr. K. W. Davison for services rendered, and Messrs. A. L. Hoffman and C. R. Brasier for acting as Honorary Auditors.

By Order of the Committee,

J. E. TREACY,
Hon. Secretary.

REVIEW.

THE PRINCIPLES AND PRACTICE OF LUBRICATION. A. W. Nash and A. R. Bowen. London: Chapman and Hall. 1929. 15s.

The authors remark in their preface that successful lubrication, which is now no longer an art, can be accomplished by the application of scientific principles in the choice and use of oils and in the design of bearings. They proceed in the introduction to discuss and clear up a number of common misconceptions and misunderstandings concerning such properties as "oiliness," viscosity, flash point and specific gravity of oils.

The treatment of the subject of friction, which is practically non-mathematical and phrased in simple language, includes sections devoted to dry or solid friction, rolling, boundary and fluid friction. The work and writings of Stanton and Goodman on rolling friction are quoted at some length. While the well-known results of Rayleigh, Deeley, Hardy, Langmuir and others in connection with the thickness of oil films, lubrication under boundary conditions and the presence of polar groups, as well as the connection between lubrication and surface or interfacial tension are given in some detail. Some of the results of Tower and Osborne Reynolds are reproduced in the section on fluid friction, together with diagrams showing the pressure distribution in the oil film in a rotating bearing, and observed co-efficients of friction under different conditions.

A considerable amount of space is devoted to methods of determining specific gravity and viscosity. Diagrams and descriptions of the well-known viscometers are included and interconversion formulæ for the different instruments appended. The section on the design and lubrication of bearings is one which it is thought may be read with advantage by all interested in lubrication problems. The composition of bearing alloys and their mechanical characteristics, the alloys suitable for particular uses as bearing metals, the precautions necessary when lining shells and mandrells and permissible bearing temperatures in relation to speed and pressure are quoted from recognised sources. The most advantageous position of oil grooves so that the lubricant is conducted to, rather than led away from, the area of greatest pressure is also dealt with. The question of actual bearing design, such as the size of journals and bearing surfaces, being presumably outside the scope of this work is not included.

A brief outline is given of the methods of manufacture and refining of mineral or petroleum oils. The Steinschneider and Schulze high vacuum distillation processes receive attention, but the modern pipe still and vacuum column methods are not mentioned, and in connection with the de-waxing of cylinder stocks, the authors class the Sharples and De Laval centrifuge plants together, whereas there are many hundreds of Sharples' machines, but as far as the writer is aware, few, if any, De Laval machines are in use for this purpose. The sources of the animal and vegetable lubricating oils and their methods of extraction are described. A useful table showing the applications of straight and blended oils from various sources is included in this section. The notes on the composition of greases and the blending and compounding of oil willl be found to be of interest.

The section on the chemistry of lubricants follows conventional lines, mention being made of the work and conclusions of Mabery, Spilker and others. While in that devoted to chemical and physical tests, current

analytical and testing practice is described. This section is intended as explanatory and supplementary to such works as Standard Methods of Testing Petroleum and its Products (I.P.T.) and the A.S.T.M. publications.

The chapter devoted to industrial lubrication practice deals with the lubrication of aircraft and motor vehicle engines, steam cylinders, turbines, air compressors, rolling mills, etc. Mechanical friction testing machines such as those of Thurston, Boult, Deeley, the Stanton pendulum and the Daimler-Lanchester worm gear machine and their methods of operation are described. The final chapter deals with such devices as filters and centrifuges which may be employed for the reconditioning of used lubricating oils.

The appendix contains physical and engineering data, tables for thermometric and viscosity conversions and charts for the latter purpose. The authors have conferred a considerable benefit on those interested in lubrication problems and have placed between two covers much information which was hitherto scattered through the literature, together with their own experience on the practical side of the subject.

The work is well illustrated. It is felt that the utility of the work to the student and investigator would somewhat increase if the bibliography were extended and references given in the text to the original sources of information.

R. W. L. Clarke.

BOOKS RECEIVED.

Annual Report of the Director of the Bureau of Standards to the Secretary of Commerce for the Fiscal Year ended June 30th, 1929. U.S. Bureau of Standards, Misc. Publ. No. 102. U.S. Govt. Printing Office, Washington, D.C. 10 cents.

Das Erdolgebiet von Mraznica in Polen. Dr. Karl Friedl. Verlag für Fachliteratur G.M.B.H., Vienna and Berlin.

This is a reprint of articles which appeared in Petroleum, 1929, Vol. 25, Nos. 37, 40 and 45.